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The Role of Coronary Computed Tomography Angiography and Cardiac Magnetic Resonance in STEMI Patients with Normal Coronary Angiography

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ABSTRACT

Usually, the diagnosis of myocardial infarction based on patient symptoms, electrocardiogram (ECG) changes, and cardiac enzymes, is not a challenge for cardiologists. The correlation between coronary anatomy and the ECG territories that present ischemic changes can help the clinician to estimate which coronary artery presents lesions upon performing a coronary angiogram. In certain situations, the diagnosis of myocardial infarction can be difficult due to the lack of correlations between the clinical and paraclinical examinations and the coronary angiogram. In some cases, patients with chest pain and ST-segment elevation on the ECG tracing present with a normal coronary angiography. In other cases, patients without important changes on the ECG can present critical lesions or even occlusions upon angiographic examination. The aim of this article is to highlight the role of noninvasive coronary magnetic resonance and multi-slice computed tomography in patients with ST-segment elevation myocardial infarction and normal coronary angiography.

Keywords: myocardial infarction, CMR, MSCT, normal coronary angiography

INTRODUCTION

The most common symptoms of myocardial infarction (MI) include chest pain and mandibular, upper extremity, or epigastric pain or discomfort that lasts more than 20 minutes; myocardial infarction is usually associated with dyspnea, fatigue, palpitations, or diaphoresis.[1] In some cases these symptoms can be nonspecific and can be a challenge for clinicians.

In patients with MI, the level of cardiac troponin is usually raised. In addition, the levels of other cardiac biomarkers, such as creatine kinase (CK), glutamic-oxaloacetic transaminase (GOT), glutamic-pyruvic transaminase (GPT), and lactate dehydrogenase (LDH), may also be raised above reference values. Typical ECG changes found in patients with MI include ST-segment elevation

in at least two contiguous leads, different morphology of T waves (hyperacute, inverted, biphasic T waves), new-onset left bundle branch block (LBBB), and Q waves.[2] The European Society of Cardiology (ESC) guidelines on myocardial revascularization established that invasive coronary angiography should be performed in the first 12 hours in patients with ST-segment elevation and elevated cardiac troponin levels.

A normal coronary angiography in a patient with ST-segment elevation on the ECG can be an important challenge for clinicians. The questions to be answered in these clinical situations are whether the coronary angiogram is falsely negative and what alternative diagnostic methods should be used.

Also, it is very important that the clinician makes a proper differential diagnosis with other causes of ST-segment elevation such as Printzmetal's disease, acute pericarditis, left bundle branch block, left ventricular hypertrophy or ventricular aneurysm, Brugada syndrome, pacemaker rhythm, raised intracranial pressure, cocaine use, acute myocarditis, aortic dissection, autoimmune vasculitis, or carbon monoxide poisoning.[3]

The prevalence of MI associated with normal coronary arteries, which may present diffuse atherosclerotic lesions but a level of stenosis below 30%, is between 1% and 12%.[4]

CLINICAL SITUATIONS WITH FALSE NEGATIVE CORONARY ANGIOGRAPHY

A normal coronary angiography does not exclude an acute MI. For example, a coronary artery plaque or coronary atherosclerosis may not reveal significant stenosis on the coronary angiogram. Because multi-slice computed tomography (MSCT) coronary angiography can provide three-dimensional images of the coronary plaques, in contrast with cardiac catheterization that provides only two-dimensional images, more accurate information on coronary plaques can be obtained by using the noninvasive imaging method. Moreover, MSCT can offer important information on the composition of the plaque and the extent of the vascular remodeling process.[5]

A retrospective study carried out in Australia, which included 714 patients presenting with ST-elevation myocardial infarction (STEMI) between 1995 and 2005, identified 41 patients with normal coronary angiographies. Specific diagnoses were established in 13 (32%) of the 41 patients and included perimyocarditis (11/41) and Takotsubo cardiomyopathy (2/41). The rest (68%) were considered to have a cryptogenic cause.[6]

Pasupathy *et al.* conducted a study in which they found a one-year mortality rate of 4.7% in patients with STEMI and normal coronary angiography.[7]

Another study by DaCosta *et al.* revealed that other causes of MI with normal coronary arteries (MINOCA) may include vascular spasm, microvascular dysfunction, and thrombophilic states. The same study reported that a third of patients with MINOCA had evidence of coronary spasm or thrombotic disorders.[8]

THE ROLE OF CORONARY COMPUTED TOMOGRAPHY ANGIOGRAPHY IN PATIENTS WITH NORMAL CORONARY ANGIOGRAPHY

Coronary computed tomography angiography (CCTA) has a high accuracy for detecting coronary atherosclerosis. CCTA is able to detect plaques according to their composition based on their densities, which can be calcified plaque, mixed plaque, and non-calcified plaques.

Panayi *et al.* conducted a descriptive study in which they included 30 patients diagnosed with MI who underwent invasive coronary angiography (ICA).9 The study included three hospitals in southeast Sweden, between 2008–2011. The coronary angiography examination revealed normal coronary arteries. All patients were evaluated with CCTA three days after ICA. In total, 24 patients presented normal coronary arteries and only six subjects had atherosclerotic lesions. In the group of patients with atherosclerosis, nine regions with non-obstructive plaques were found.[9]

THE ROLE OF CARDIAC MAGNETIC RESONANCE IN PATIENTS WITH NORMAL CORONARY ANGIOGRAPHY

The role of cardiac magnetic resonance (CMR) in determining the presence of ischemia in patients with MI improved in the last years. It is very important for clinicians to have an accurate diagnosis in order to administer an optimal medical treatment. For example, the diagnosis of a non-ischemic etiology may not require antiplatelet therapies.[6] CMR is a very useful tool in highlighting the myocardial edema or inflammation and in diagnosing acute myocarditis.[10]

The most accurate and validated function of CMR for the diagnosis of MI is delayed enhancement CMR (DE-CMR), which can measure the infarction size in association with the levels of serum cardiac enzymes. Also, DE-CMR is superior to single-photon emission computed tomography (SPECT) in detecting subendocardial infarctions and can also accurately diagnose microinfarctions by

using the high spatial resolution function, even in 1 g of myocardial tissue.[9]

It also seems that gender may be an important risk factor for STEMI with normal coronary angiography, women being more affected than men. In a study reported by Sedlak *et al*., 10.2% of patients with MINOCA were females, compared to 6.8% males.[11]

A prospective study conducted by Reynolds *et al*. investigated the mechanisms involved in the occurrence of MINOCA in 42 female patients.[12] After one week from the acute event, the patients underwent CMR imaging, which revealed that 39% had late gadolinium enhancement of CMR — the most common sign of myocardial ischemia — and 53% presented myocardial edema upon T2 sequence examination, which appears as a hyperintensity in the affected area.[12]

CMR VERSUS MSCT CORONARY ANGIOGRAPHY

A meta-analysis by Schuijf *et al*. showed that MSCT has higher accuracy compared to MRI in identifying coronary stenoses, possessing a sensitivity of 85% and a specificity of 95% compared to CMR, which presents a specificity of 72% and a sensitivity of 87%.[13]

In a single-center trial that enrolled 108 subjects with suspected coronary artery disease, Dewey *et al*. showed that MSCT was more specific in viewing the coronary lesions compared to MRI; however, due to latest developments in CMR, its diagnostic precision has gradually improved in the last years.[14] The ability of CMR to detect information on ischemia induced by stress and myocardial viability are extremely important in making the best possible therapeutic decision and to improve the outcome of subjects with MI.[15] The role of CMR in assessing cardiac function, myocardial perfusion and viability, as well as coronary imaging, is a major force in the field of noninvasive cardiovascular imaging.[16]

One of the most important advantages of CCTA is the imaging of the coronary artery anatomy and a short examination time, during a single breath-hold.[17]

CCTA examination in patients with MI can provide a highly accurate visualization of the coronary anatomy and arterial lumen. In addition, CCTA can detect severe stenoses or occlusions that are responsible for the MI.[17] This modern medical technique provides the ability of assessing the coronary artery wall, atherosclerotic plaques, and the presence or absence of coronary artery disease (CAD).[18] One of the most important roles of CCTA is that it can provide information on atherosclerotic plaque morphology and composition. Plaques can be classified in three groups: calcified, non-calcified, and mixed (partially calcified).[19] CCTA underestimates the size of the non-calcified plaques and overestimates the size of calcified ones. For example, a plaque that contains a high percentage of fibrosis has high attenuation on CCTA; on the other hand, necrotic areas in the myocardium are characterized by a low attenuation.[20] The determination of plaque composition with the use of CCTA can be challenging due to the influence of various factors, including the size of the necrotic area, the lumen thickness, the density of the intraluminal contrast medium, slice thickness, and reconstruction filters.[21]

One of the most important advantages of coronary MR angiography over cardiac CT is that it does not expose the examined subject to radiations. A study proved that CCTA is not very accurate in diagnosing heavily calcified plaques. Coronary MR angiography can have better diagnostic accuracy in detecting CAD in subjects with increased calcium scores. Another important advantage of CMR is the lack of using contrast agents.[21,22]

CONCLUSIONS

Even if invasive coronary angiography is one of the most accurate methods for the diagnosis and treatment of myocardial infarction, in some occasions it cannot provide complete information to sustain the diagnosis. In these situations, the role of modern noninvasive techniques, such as CCTA and CMR, is highly important. CMR is more accurate than CCTA in evaluating the perfusion and viability of the myocardium and cardiac function. Also, CMR may provide better diagnostic performance compared to CCTA in detecting coronary artery disease in patients with high calcium scores. CCTA can provide a detailed visualization of the coronary anatomy and also provide information on plaque morphology and composition. The important advantage of CMR over CCTA is that CMR does not expose the subject to radiations.

CONFLICT OF INTEREST

Nothing to declare.

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